1. An apparatus for preparing a blood component for cryopreservation by mixing the blood component with a volume of cryopreservation solution that exposes the blood component to a risk of osmolarity shock, the apparatus comprising:

at least one variable-speed pump coupled to the volume of cryopreservation solution and to the blood component, operation of the pump at a given speed defining a respective flow rate of cryopreservation solution to the blood component; and

a controller operably coupled to the at least one pump so as to control the rate at which cryopreservation solution is delivered to the blood component, the controller configured to dynamically adjust the flow rate of the cryopreservation solution to reduce the risk of osmolarity shock to the blood component.

2. The apparatus of claim 1 further comprising an anti-bacterial filter disposed between the cryopreservation solution and the blood component.

3. The apparatus of claim 2 wherein the controller dynamically adjusts the cryopreservation flow rate so as to maintain a substantially linear increase of blood component osmolarity.

4. The apparatus of claim 3 wherein the controller is further configured to determine repeatedly the amount of cryopreservation solution added to the blood component, calculate a new flow rate based on the determined amount of

cryopreservation solution and adjust the at least one pump to deliver cryopreservation solution at the new flow rate.

5. The apparatus of claim 4 wherein the controller determines the amount of cryopreservation solution, calculates the new flow rate and ȧdjusts the at least one pump on a real time basis.

6. The apparatus of claim 5 wherein the controller is further configured to determine a requisite volume of cryopreservation solution to achieve a desired cryopreservative concentration within the blood component.

7. The apparatus of claim 6 wherein a tube connects the cryopreservation solution to the blood component and a pressure probe is disposed in the tube downstream of the at the least one pump, the pressure probe providing a corresponding pressure signal to the controller which is further configured to de-activate the at least one pump if the pressure signal exceeds a pre-determined threshold.

9 ~~8~~. The apparatus of claim 1 wherein the blood component is red blood cells and the controller is configured to adjust the speed of the at least one pump so that the flow rate of cryopreservation solution is substantially given by the following equation:

$$K\,[V_i * (W * Hct_i /100) + V_g]^2 / [V_i * (W * Hct_i / 100) * (O_i - O_g)]$$

where,

K is the selected rate of increase in osmolarity of the red blood cells,

V_i is the volume of red blood cells,

W is the volumetric percentage of water in the red blood cells,

Hct_i is the hematocrit level of the red blood cells before cryopreservation.

V_g is the volume of cryopreservation solution that has already been added to the red blood cells prior to the current flow rate calculation,

O_i is the osmolarity of the red blood cells before cryopreservation, and

O_g is the osmolarity of the cryopreservation solution.

~~9~~ 10. The apparatus of claim ~~8~~ 9 wherein the controller is configured to initially adjust the speed of the at least one pump so that the initial flow rate of cryopreservation solution is substantially given by the following equation:

$$K * V_i * (W * Hct_i / 100) / (O_i - O_g).$$

~~10~~ 11. The apparatus of claim ~~9~~ 10 wherein the controller is further configured to determine the volume of red blood cells, V_i, substantially in accordance with the following equation:

$$NW_i / [1.1 * Hct_i / 100 + 1.026 * (1 - Hct_i / 100)]$$

where,

NW_i is the net weight of the red blood cells prior to cryopreservation.

~~11~~ 12. The apparatus of claim ~~10~~ 11 further comprising a shaker platform for agitating the blood component as the cryopreservation solution is being delivered thereto.

~~12~~ 13. The apparatus of claim 1 further comprising a shaker platform for agitating the blood component as the cryopreservation solution is being delivered thereto.

~~13~~ 8. The apparatus of claim 2 wherein the anti-bacterial filter has an operating pressure range and the controller is further configured to prevent the pressure of cryopreservation solution at the anti-bacterial filter from exceeding the operating range.

14. A method for preparing a blood component for cryopreservation by mixing the blood component with a volume of cryopreservation solution that exposes the blood component to a risk of osmolarity shock, the method comprising the steps of:

determining the volume of cryopreservation solution needed to obtain a desired concentration of cryopreservative within the blood component;

coupling the volume of cryopreservation solution to the blood component by means of at least one variable-speed pump such that operation of the pump at a given speed defines a respective flow rate of cryopreservation solution to the blood component; and

dynamically adjusting the flow rate of the cryopreservation solution by periodically changing the speed of the at least one pump to reduce the risk of osmolarity shock to the blood component.

15. The method of claim 14 wherein the step of dynamically adjusting comprises the step of changing the speed of the at least one pump so that the flow rate of cryopreservation solution is substantially given by the following equation:

$$K\,[V_i * (W * Hct_i /100) + V_g]^2 / [V_i * (W * Hct_i / 100) * (O_i - O_g)]$$

where,

K is the selected rate of increase in osmolarity of the red blood cells,

V_i is the volume of red blood cells,

W is the volumetric percentage of water in the red blood cells,

Hct_i is the hematocrit level of the red blood cells before cryopreservation,

V_g is the volume of cryopreservation solution that has already been added to the red blood cells prior to the current flow rate calculation,

O_i is the osmolarity of the red blood cells before cryopreservation, and

O_g is the osmolarity of the cryopreservation solution.

16. The method of claim 15 further comprising the step of agitating the blood component as the cryopreservation solution is being delivered thereto.

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~~17~~. An apparatus for diluting a thawed, cryopreserved blood component with a volume of a dilution solution that exposes the blood component to a risk of osmolarity shock, in preparation for recovery of the blood component, the apparatus comprising:

means for coupling the dilution solution to the blood component;

at least one variable-speed pump disposed in the coupling means, operation of the at least one pump at a given speed defining a respective flow rate of dilution solution to the blood component; and

a controller operably coupled to the at least one pump so as to control the rate at which dilution solution is delivered to the blood component; the controller configured to dynamically adjust the flow rate of the dilution solution to reduce the risk of osmolarity shock to the blood component.

~~18~~ 15. The apparatus of claim ~~17~~ 14 wherein the controller dynamically adjusts the dilution solution flow rate so as to maintain a linear decrease of blood component osmolarity.

~~19~~ 16. The apparatus of claim ~~18~~ 15 wherein the blood component is red blood cells and the controller is configured to adjust the speed of the at least one pump so that the flow rate of dilution solution is substantially given by the following equation:

$$K_D [V_i * (W * Hct_i/100) + V_s]^2 / [V_i * (W * Hct_i/100) * (O_i - O_s)$$

where,

K_D is the desired osmolarity rate decrease,

V_i is the volume of the thawed red blood cells after dilution with the hypertonic solution,

W is the volumetric percentage of water in the red blood cells,

Hct_i is the hematocrit level of the thawed red blood cells after dilution with the hypertonic solution,

V_s is the volume of washing solution that has already been delivered to the thawed red blood cells,

O_i is the osmolarity of the thawed red blood cells after dilution with the hypertonic solution, and

O_s is the osmolarity of the washing solution.

~~20~~ 17. The apparatus of claim ~~19~~ 16 wherein the controller is configured to initially adjust the speed of the at least one pump so that the initial flow rate of dilution solution is substantially satisfied by the following equation:

$K_D * V_i * (W * Hct_i / 100) / (O_i - O_s)$.

~~21~~ 18. The apparatus of claim ~~20~~ 17 further comprising a shaker platform for agitating the blood component as the dilution solution is being delivered thereto.

22. A method for diluting a thawed, cryopreserved blood component with a volume of a dilution solution that exposes the blood component to a risk of osmolarity shock, in preparation for recovery of the blood component, the method comprising the steps of:

Hct_i is the hematocrit level of the thawed red blood cells after dilution with the hypertonic solution,

V_s is the volume of washing solution that has already been delivered to the thawed red blood cells,

O_i is the osmolarity of the thawed red blood cells after dilution with the hypertonic solution, and

O_s is the osmolarity of the washing solution.

25. The method of claim 24 wherein the step of dynamically adjusting further comprises initially adjusting the speed of the at least one pump so that the initial flow rate of dilution solution is substantially given by the following equation:

$$K_D * V_i * (W * Hct_i / 100) / (O_i - O_s).$$

26. The method of claim 25 further comprising the step of agitating the thawed blood component as the dilution solution is being delivered thereto.

19 ~~27~~. An apparatus for preparing a blood component for cryopreservation by mixing the blood component with a volume of cryopreservation solution that exposes the blood component to a risk of osmolarity shock, and for diluting a thawed, cryopreserved blood component with a volume of a dilution solution that also exposes the blood component to a risk of osmolarity shock, in preparation for recovery of the blood component, the apparatus comprising:

at least one variable-speed pump coupled to the blood component and selectively coupled to either the volume of cryopreservation solution or the volume of dilution solution, operation of the pump at a given speed defining a respective flow rate of either cryopreservation solution or dilution solution to the blood component; and

a controller operably coupled to the at least one pump so as to control the rate at which either cryopreservation solution or dilution solution is delivered to the blood component, the controller configured to dynamically adjust the flow rate of either the cryopreservation solution or the dilution solution to reduce the risk of osmolarity shock to the blood component.

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coupling the volume of dilution solution to the thawed blood component by means of at least one variable speed pump such that operation of the pump at a given speed defines a respective flow rate of dilution solution to the blood component;

dynamically adjusting the flow rate of the dilution solution, by periodically changing the speed of the at least one pump, to reduce the risk of osmolarity shock to the thawed blood component.

23. The method of claim 22 further comprising the step of diluting the thawed blood component with a volume of a hypertonic solution prior to delivering the dilution solution, the hypertonic solution having an osmolarity that is substantially similar to the osmolarity of the blood component.

24. The method of claim 23 wherein the blood component is red blood cells and the step of dynamically adjusting comprises the step of changing the speed of the at least one pump so that the flow rate of dilution solution is substantially given by the following equation:

$$K_D [V_i * (W * Hct_i/100) + V_s]^2 / [V_i * (W * Hct_i/100) * (O_i - O_s)$$

where,

K_D is the desired osmolarity rate decrease,

V_i is the volume of the thawed red blood cells after dilution with the hypertonic solution,

W is the volumetric percentage of water in the red blood cells,